Study on Comparison of Self Curing of Concrete by Using Normal Coarse Aggregate and Recycled Coarse Aggregate

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Abstract- **A self – curing concrete is provided to absorb water from atmosphere to achieve better hydration of cement in concrete which solves the problem of lowered cement hydration because of improper curing and thus unsatisfactory properties of concrete. The present investigation involves the use of self – curing agent viz., polyethylene glycol (PEG) of molecular weight 6000 (PEG 6000) for dosages ranging between 0.5 to 2% by weight of cement added to mixing water. The experimental program was planned for a total of 120 cubes, 120 cylinders and120 prisms were cast which involves different dosages (0%, 0.5%, 1% and 2%) of self-curing agent PEG-6000 for four different mixes (Mix 30 and mix 40), Under different curing conditions (indoor, conventional) with different aggregates (normal coarse aggregate and recycled coarse aggregate).Comparative studies were carried out for self-curing of recycled coarse aggregate and self-curing of normal coarse aggregate. Comparative studies were carried out for water retentivity, compressive strength, split tensile strength, flexural strength after 28 days for conventional cured and self-cured concrete. The properties of self – cured concrete are at least comparable and sometime better than those of concrete with traditional curing. The experimental investigation shows that increase in SCA from 0% to 2% there is increase in strengths obtained. From concrete using normal coarse aggregate has shown a greater compressive strength, Flexural Strength, Splitting Tensile Strength compared to recycled coarse aggregate. And when compared to conventional curing there is a greater strength obtained for self-curing concrete.**

I. INTRODUCTION

Curing is the process of controlling the rate and extent of moisture transport from concrete during Cement hydration. It may be either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time in days, and even weeks rather than hours curing must be undertaken for a reasonable period of time, if the concrete is to achieve its potential strength and durability. Curing may also encompass the control of temperature since this affects the rate at which cement hydrates. The curing period may depend on the properties required of the concrete, the purpose for which it is to be used, and the ambient conditions, i.e. the temperature and relative humidity of the surrounding atmosphere. Curing is designed primarily to keep the concrete moist, by preventing the loss of moisture from the concrete during the period in which it is gaining strength.

1.1.1 Conventional Curing Methods

Methods of curing concrete fall broadly into the following categories:

Minimise moisture loss from the concrete, for example by covering it with a relatively impermeable membrane.

Prevent moisture loss by continuously wetting the exposed surface of the concrete.

Steam curing.

Ponding or spraying the surface with water.

Difficulties in conventional curing methods

For the vertical member it is not possible to keep the surface moist as in case of the flat surfaces.

In the places where there is scarcity of water.

In the places where manual curing is not possible A human error may leads to the cracking in the member and also decreases its strength i.e when curing water is not provided at the right time.

1.2 Self Curing

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However, good curing is not always practical in many cases. Several investigators explored the possibility of accomplishing self-curing concrete. Therefore, the need to develop self-curing agents attracted several researchers. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in the concrete construction in the new millennium. Curing of concrete plays a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day (i.e., each 1cu.m of concrete requires about 3cu.m of water for construction most of which is for curing).

Excessive evaporation of water (internal or external) from fresh concrete should be avoided; otherwise, the degree of cement hydration would get lowered and thereby concrete may develop unsatisfactory properties. Curing operations should ensure that adequate amount of water is available for cement hydration to occur. This investigation discusses different aspects of achieving optimum cure of concrete without the need for applying external curing methods. The effect of curing, particularly new techniques such as "self-curing", on the properties of high performance concrete is of primary importance to the modern concrete industry

halt Pavement (RAP), Reclaimed Asphalt Aggregate (RAA), Glass Cullet, Scrap Tyres, Used Foundry Sand

Conclusions

Workability of concrete was found to increase by 9% when self-curing agents are added to the concrete. The compressive strength at 7days and 28 days for Mix A1 and Mix A2 self-curing concrete was found to be optimum at 2% PEG6000 dosage; and in case of Mix B1 and MixB2 self-curing concrete the optimum value was observed at 1%PEG6000 dosage. The compressive strength at 28 days for M30 self-curing concrete prepared by natural coarse aggregate is 38.61MPa for mix A1H2 is approximately equal when compared with conventional concrete A1OW. The compressive strength for M40 self-curing concrete prepared by natural coarse aggregate is 48.3MPa for mix A2H2 is approximately equal when compared with conventional concrete A2OW. The compressive strength approximately 17.5% more for the concrete using normal coarse aggregate compared to the concrete using recycled coarse aggregate for 28 days in both the mixes(M30,M40) The compressive Strength approximately 3% more for self-curing concrete compared to the conventional curing concrete for 28 days in both the mixes(M30,M40) The splitting tensile strength approximately 7% more for natural coarse aggregate concrete compared to recycled coarse aggregate concrete for 28 days in both mixes (M30, M40). The splitting tensile strength approximately 3.1% more for self-curing concrete compared to the conventional curing concrete for 28 days in both mixes(M30, M40) The flexural strength approximately 5% is more for natural coarse aggregate concrete compared to recycled coarse aggregate concrete 28 days mixes (M30, M40). The flexural strength approximately 2% more for self-curing concrete compared to the conventional curing concrete for 28 days in both mixes (M30, M40). The maximum weight loss in the concrete occurs at 0% for all the mixes (Mix A1, Mix A2, MixB1, MixB2) of self-curing agent and increases with increases in percentage of self-curing agent.

SCOPE FOR FUTURE STUDIES

The effect of self-curing agent on the microstructure and pore size distribution of the self-curing concrete requires additional study.

Sorptivity and durability studies for sulphate salts and chloride induced corrosion on self-curing concrete need to investigate. Mix design procedures for development of self-curing concrete and fibre reinforced self-curing concrete are to established. Further in depth investigation is to done for choosing optimum dosage of self-curing agent in strength and durability point of view. Study on use of light weight aggregate and recycled aggregate is to be carried which possess more Absorption capacities.

II. LITERATURE REVIEW

WEN-CHEN JAU (SELF CURING CONCRETE)(2008)

The objective of the research was to find out the effect of high performance self-curing agent on strength characteristics of self-compacted concrete in comparison with ordinary concrete(withdifferent curing conditions).The self-curing agent used in this study was poly acrylic acid (PAA) and polyvalent alcohol. These two chemicals are most hydrophilic in nature. The dosage of self-curing agent was 1% and 2% by weight of cement. Compressive strength and water retentivity test was carried under different relative humidity conditions like 50%, 67.5% and 85%.

Claims on internal curing compositions

A cementitious mix comprising of cement and aggregate, further including an internal curing concentrate which includes a glycol, a wax and water. The cementitious mix wherein the glycol was a polyethylene glycol of molecular weight 200 and wax was selected from the group consisting of paraffin wax. A cementitious mix including an internal curing concentrate wherein the internal curing concentrate comprises about 10% polyethylene glycol, about 57% paraffin wax, and about 33% water. A cementitious mix wherein the internal curing composition was present in the cementitious mix in an amount of about 5 l/m3.

A.S. EL- DIEB (2007

The objective of the research was to find out the water retention capacity and degree of hydration and moisture transport by using self-curing agent and compare to conventional curing of concrete. The self-curing agent used in this study was water soluble polymeric glycol (polyethylene glycol). The dosage of self-curing agent was 0.02% by weight of cement. The dosage was kept constant for all the self-curing concrete mixes.The investigation aimed at studying on concrete with different quantities of cement (350-450kg/m3) at different water- cement ratios (0.3-0.4) both for self, conventional and air-curing concrete and compare the results for different test.

The following could be concluded from the results obtained in this study.

Water retention for the concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time. Self-curing concrete suffered less self-desiccation under sealed conditions compared to conventional concrete. Self-curing concrete resulted in better hydration with time under drying condition compared to conventional concrete. Water transport through self-curing concrete is lower than air-cured conventional concrete.

Water sorptivity and water permeability values for self-curing concrete decreased with age indicating lower permeable pores percentage as a result of the continuation of the cement hydration.

A.S. El-Dieb, T.A. El-Maaddawy and A.A.M. Mahmoud (2011):-

The study investigates using laboratory synthesized water-soluble polymers: polyethylene glycol (PEG) and polyacrylamide (PAM) as self-curing agents and its effect on the degree of hydration, water absorption, permeable pores and microstructural characteristics of Portland cement mixtures without and with 8% silica fume replacement. Portland cement mixtures including PEG or PEG+PAM as self-curing agents showed a better quality compared to that of the non-cured mixtures. Mixtures incorporating 8% silica fume including a mixture of PEG and PAM as self-curing agent had a better quality compared to that of the mixture including only PEG especially at later ages.Polyethylene-glycol (PEG) was used alone with a dosage of 0.02% by weight of cement. Polyacrylamide (PAM) was used in conjunction with PEG as a second alternative for self-curing agent. The dosage of PEG and PAM was 0.02% by weight of the cement, PEG dosage was 0.013% and that of PAM was 0.007%. M. Collepardi, A. Borsoi, S. Collepardi, R. Troli and M. Valente (2006):-The purpose of this research work was to make a drying shrinkage-free concrete (SFC), even in non-wet curing conditions. This concrete was produced by the combined use of:

A water-reducing admixture, based on polycarboxylate (PA), in order to reduce both the mixing water and cement, and increase the amount of aggregate; A special polycarboxylate (PA/SRA) including, in its molecularstructure, a shrinkage-reducing admixtures (SRA) based on polyethylene glycol capable of reducing the surface tension of liquid water filling the capillary pores;

An expansive agent based on a special calcium oxide (CaO) manufactured in a kiln at Relatively high temperatures (about 1000°C) with a particle size distribution in the range of 10-125µm.

Five concrete mixtures were manufactured all at the w/c of 0.50 and a slump level in the range of 170-200 mm at 30 minutes after mixing

Two different curing conditions were adopted:- according to the first method, based on ASTM 845-90, the specimens after de-moulding at 6 hours were cured under lime-saturated water; then after 3 days they were exposed to air with R.H. of 50% at 20°C for 6 months; according to a modified method, the de-moulded specimens at 6 hours were protected from drying by a polyethylene sheet up to 3 days in order to simulate the curing conditions occurring realistically into the formworks; then the specimens were exposed to the air at 20°C and at a RH of 50% from 3 days up to 6 months.

The combined use of a CaO-based expansive agent and a polycarboxylate-based water-reducer, containing in its molecular structure a chemical group which acts as shrinkage-reducing admixture (SRA), is very effective in manufacturing a drying shrinkage-free concrete even in the absence of any wet-curing.

There are three distinct effects to explain this action: First, due to the usual water reduction caused by the polycarboxylate super plasticizer at a given w/c, there is a reduction in the volume of the cement paste and an increase in the amount of the aggregate. Both are responsible for significant reduction in the drying shrinkage. Second, due to the alkaline environment of the aqueous solution caused by the cement hydration, the SRA group in the form of a polyethylene glycol is released and this is

Responsible for a further reduction in the drying shrinkage related to decrease in the surface tension of water which is responsible for the reduction in the capillary pressure.Third, the expansion caused by the CaO hydration is enhanced by the presence of the SRA group released by the PA/SRA super plasticizer in the alkaline aqueous phase filling the capillary pores of the cement paste. Consequently, crack-free concrete can be made even in the absence of early wet-curing which, in general is needed to manufacture shrinkage-compensating concrete. R.K. Dhir, P.C. Hewlett and T.D. Dyer (1994):-This paper reports the results of a series of durability tests conducted on self-cure concrete. The tests were the initial surface absorption test, the potential difference (PD) chloride diffusion test, and depth of carbonation, half-cell corrosion potential and measurement of freeze / thaw resistance.

Three mixes were used throughout the programme: one containing only OPC as a binder, one containing a 40% GGBS cement replacement and one containing PFA as a 30% cement replacement. Two dosages were used: 0.005M and 0.l00M.

Two sets of control specimens were cast, kept under damp hessian and polythene for 24 hours and then stripped. One set was cured in air at 20°C/ 60%RH for 28 days. The other set were kept for the same amount of time in the same conditions, but sealed in a water-resistant plastic film to ensure that no moisture was lost. The self-cure concrete specimens were also cured in air at 20°C /60%RH.

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The following could be concluded from the results obtained in this study

With respect to surface quality, chloride diffusion, carbonation, corrosion potential and freeze/thaw resistance self-cure concrete provides improved performance when compared to air cured specimens.

The improvements in concrete durability properties are dependent on chemical dosage. At the highest dosage used in this study properties approaching, and in some cases as good as, those characteristic of the film cured control were achieved.

3.2 Materials Used

The different materials used in this investigation are

Cement

Fine Aggregate

Coarse aggregate
Recycled coarse aggregate
Water
Polyethylene glycol (PEG)
Cement

The cement used in the investigation was 53-grade ordinary Portland cement conforming to IS 12269-1987. It was taken from a single lot and stored properly throughout the programme. The physical properties of cement are shown in table 3.1

Table 3.1Physical properties of cement

Specific gravity	3.14
Initial setting time	75 min
Final setting time	215 min

3.2.1 Fine Aggregate

The fine aggregate (sand) that falls in zone-II conforming to IS 383-1970 was used. The fine aggregate used was obtained from a nearby river course. The sand obtained from quarry was sieved through all the sieves (i.e. 2.36mm, 118mm, 600µ, 300µ and150µ). Sand retained on each sieve was filled in different bags and stacked separately for use. To obtain zone- II sand correctly, sand retained on each sieve is mixed in appropriate proportion. The physical property of fine aggregate and proportion in which each size fraction is mixed is shown in table 3.2&3.3 respectively.

Table 3.2.Physical Properties of fine aggregate

Fineness modulus	2.80
Bulk density	1.37gm/cc
Specific gravity	2.60

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3.2.3 Coarse Aggregate

The coarse aggregate used is from a local crushing unit having 20mm nominal size. 20mm well-graded aggregate according to IS-383 is used in this investigation. The coarse aggregate procured from quarry was sieved through all the sieves (i.e. 16mm, 12.5mm. 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, coarse aggregate retained on each sieve is mixed in appropriate proportions. The physical properties and proportions in each fraction are shown in table 3.2.4& 3.2.5 respectively.

Table 3.4 physical properties of coarse aggregate

Fineness modulus	7.35
Bulk density	1.540gm/cc
Specific gravity	2.67

3.2.4 Recycled Coarse Aggregate

The Recycled coarse aggregate used is from a lab crushing unit having 20mm nominal size. 20mm well-graded aggregate according to IS-383 is used in this investigation. The Recycled coarse aggregate procured from lab was sieved through all the sieves (i.e. 16mm, 12.5mm. 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, recycled coarse aggregate retained on each sieve is mixed in appropriate proportions.

3.2.5 Water

The water, which is used for making concrete should be clean and free from harmful impurities like oil, alkalis, acids etc. Ordinary potable water available in the laboratory was used for making and curing concrete. The quality of water was found to satisfy the requirements of IS: 456 –2000

3.2.6 Polyethylene glycol (PEG)

Polyethylene glycol is a condensation polymers of ethylene oxide and water with the general formula H $(OCH_2CH_2)_nOH$, where n is the average number of repeating ox ethylene groups typically from 4 to about 180. The low molecular weight members from n=2 to n=4 are diethylene glycol, triethylene glycol and tetra ethylene glycol respectively, which are produced as pure compounds. The low molecular weight compounds up to 700 are colourless, odourless viscous liquids with a freezing point from 10ºC (diethylene glycols), while polymerized compounds with higher molecular weight than1,000 are wax like solids with melting point up to 56-61ºC for n 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be water-soluble. The specifications of PEG6000 are shown in table 3.2.8.It is soluble also in many organic solvents including aromatic hydrocarbons (not aliphatic). They are used to make emulsifying agents and detergents, and as plasticizers, humectants, and water-soluble textile lubricants. The wide range of chain lengths provides identical physical and chemical properties for the proper application selections directly or indirectly in the field of; Alkyd and polyester resin preparation to enhance water dispersability and water-based coatings. Anti-dusting agent in agricultural formulations Brightening effect and adhesion enhance in electroplating and electroplating process. solvent properties. Coupling agent, humectants, solvent and lubricant in cosmetics and personal care bases. Dimensional stabilizer in wood working operations Dye carrier in paints and inks Heat transfer fluid formulation and defoamer formulations Low volatile, water soluble and noncorrosive lubricant without staining residue in food and package process.

Paper coating for anti-sticking, colour stabilizing, good gloss.

Plasticizer to increase lubricity and to impart a humectants property in ceramic mass, adhesives and binders.

Softener and antistatic agent for textiles

Soldering fluxes with good spreading property.

Polyethylene glycol is non-toxic, odourless, neutral, lubricating, non-volatile and no irritating and is used in a variety of pharmaceuticals and in medications as a solvent, dispensing agent, ointment and suppository bases, vehicle, and tablet excipient. Chemical structure of PEG is shown below.

Polyethylene glycol is produced by the interaction of ethylene oxide with water, ethylene glycol or ethylene glycol oligomers. 3.3

Specimens moulded

Cube specimens:

Cube size: cube moulds of 150 x 150 x 150 mm size.

Total number of cubes casted: 120.

Cylinder specimens:

Cylinder size: cylinder moulds of 150 mm diameter x 300 mm length.

Total number of cylinders casted: 120.

Prism specimens:

Prism size: prism moulds of 100 mm x 100 mm x 500 mm size.

Total number of prisms casted: 120.

Material quantity was shown in the table 3.3

3.4 Preliminary Investigation

3.4.1 Cement

Test for Properties of Cement by Using Self-Curing Agent (PEG)

.4.1. a) Standard Consistency of Cement

For finding out initial setting time, final setting time and soundness of cement, and strength a parameter known as standard consistency has to be used. The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from the top of the mould.

The apparatus is called Vicat Apparatus. This apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as P. In this study, consistency test is performed as per standard procedures using Vicat apparatus.

3.4.1. b) Initial time of cement

An arbitrary division has been made for the setting time of cement as initial setting time a final setting time. It is difficult to draw a rigid line between these two arbitrary divisions.

The time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity.

3.4.1 c) Final setting time of cement

The time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.

In actual construction dealing with cement paste, mortar or concrete certain time is required for mixing, transporting, placing, compacting and finishing. During this time cement paste, mortar, or concrete should be in plastic condition. The time interval for which the cement products remain in plastic condition is known as the initial setting time. Normally a minimum of 30 minutes is given for mixing and handling operations. The constituents and fineness of cement is maintained in such a way that the concrete remains in plastic condition for certain minimum time. Once the concrete is placed in the final position, compacted and finished, it should lose its plasticity in the earliest possible time so that it is least vulnerable to damages from external destructive agencies. This time should not be more than 600 minutes. In this study initial and final setting time tests are performed as per standard procedures

3.5 Detailed Investigation on concrete

3.5.1 Mix design

In this study, mix design is done by three methods

IS CODE

In order to obtain strength around 30Mpa and 40Mpa for Mix A1&B1 and Mix A2&B2respectively. Number of trails were conducted to obtain the desired strength and to maintain good workability (slump of about 100mm) and finally acquired four mix proportions as Mix A1 (M30), A2 (M40) and Mix B1 (M30), B2 (M40). To obtain good workability and desired strength the optimum water cement ratio used in Mix A is 0.40 and

Super-plasticizer is used in the mix and in Mix B the optimum water cement ratio is 0.38 and no super-plasticizer is used in the mix.

3.5.2 Test for Fresh Properties of Concrete

3.5.2.a) Slump Test

Slump test is the most commonly used method of measuring workability of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability. In this case study slump test is done according to IS 456-2000 Specifications.

3.5.2.b) Compacting Factor Test

It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete are insensitive to slump test. As shown in Fig 3.2

Fig 3.5.2 (b) Compacting Factor apparatus

This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted.

3.5.3 Test for Properties of concrete

3.5.3. a) Water Retentivity Test

Water Retentivity is the ability of the substance to retain water.

To perform the water Retentivity test, the cubes were weighed for every 3 days from the date of casting. Weight loss for the specimens in controlled curing, and weight gain for the conventional curing are noted and their behaviour is plotted in graph against number of days of curing. As shown in the plate 7 and 83.6 Testing of Specimens

After the specimen prepared for testing on universal testing machine to find the Mechanical properties such as compressive strength on cubes, flexural strength on prisms, splitting tensile strength on cylinders.

3.6.1 Testing Procedure for Compressive Strength

The specimens were tested in accordance with IS 516:1969, the testing was done on universal compression testing machine of 2000kN velocity. The machine has the facility to control the rate of loading with a control valve. The machine has been calibrated to the required standards. The platens are cleaned; oil level is checked and kept ready in all respects for testing. As shown in the plate 4 and 11.

It is placed on the machine such that the load is applied centrally the smooth surfaces of the specimen are placed as the bearing surfaces. The top plate is brought in contact with the specimen by rotating the handle. The oil pressure valve is closed and the machine is switched ON. A uniform rate of loading 140lg/sq.cm/min is maintained. The maximum load at failure at which the specimen breaks and the average value is taken as the mean strength.

The compressive strength is taken as the load applied on the specimen divided by the area of the load bearing surface of the specimen (P/A).

3.6.2 Testing Procedure for Flexural Strength

Flexural strength is expressed in terms of modulus of rupture, which is the maximum stress at the extreme fibres in bending. It is calculated by flexure formula. After removal of the beam

Specimen from the controlled curing, they are tested on the load frame of 20kN capacity in accordance with IS 9399:1679. The load frame is provided with two rollers at a

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